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Differential Preference of the Flower-Dwelling Thrip, *Thrips hawaiiensis* (Morgan) (Thysanoptera: Thripidae), to Some Gladiolus Cultivars[1]

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Abstract: Flower-dwelling thrip, *Thrips hawaiiensis* (M.) appeared to have certain appetite for flowers of some cultivars of gladiolus. Cultivar T512 was the most favorite one for this thrip. White Prosperity and T609 also had good performance, but the other four cultivars, Red Beauty, Albert, Applause and Peter Pears seemed to have little seduction for the thrip. Experiments were conducted both in the field and laboratory. All data were shown as No. of thrips/flower or No. of thrips/spike. The floral scent was proved to be a major factor influencing the thrip's choice of cultivars of gladiolus. In addition, color hue could be another improtant factor. Fully blooming gladiolus flowers had potent attraction to the thrip, and their performance was proportional to the degree of development of flower buds. The conspicuous color contrast, floral scent, floral shape and nectar of an inflorescent gladiolus flowers in concert played important roles in guiding the thrip flying toward them. These attraction factors of gladiolus flowers to the thrip are discussed.

Introduction

Cut flower is one of the exportable produces of Taiwan. The climate of this island is suitable for year-around cultivation of gladiolus (Wang 1982) and the consumption of cut flowers has increased considerably in the past few years. Therefore gladiolus has received more and more attention. Several insect pests on gladiolus including three flower-dwelling thrips, *Thrips hawaiiensis* (M.), *Frankliniella formosae* M. and *Haplothrips chinensis* P. have been reported in Taiwan (Wang 1982).

Color hues (Gibb 1950; Trimble & Brach 1985; Bhuyan & Das 1985; Katsoyannos et al. 1985), brightness (Katsoyannos et al. 1985), scents (Kullenberg et al. 1984; Numata et al. 1985; Hodgson & Elbakhiet 1985; Young 1986), texture (Lovell 1918) and shape

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(Proctor & Yoe 1972; Hodgson & Elbakhiet 1985) of the plants, play important roles as insects seek their hosts for feeding, shelters, and oviposition sites.

Insects would not visit flowers unless some sort of reward is held out to them, and the reward offered by many plants to insect visitors is nectar (Gibbs 1950). Flowers with nectaries are likely to be frequented by the flower-dwelling or visiting insects for their nectar and pollens, while those without would be visited only for pollens. Flowers are also occasionally visited by insects seeking shelter or making mistaken landing (Proctor & Yoe 1972).

The floral scents of anisaldehyde significantly increased the catches of seven species of flower-dwelling thrips (Kirk 1985). This experiment on attraction of *Thrips flavus* by gladiolus of different colors indicated that color was one of the factors influencing *T. flavus*'s choice of flowers. We also found *T. hawaiiensis* (M.) had the tendency to appear more frequently on some cultivars of gladiolus. This paper describes the phenomenon and the distribution of the thrip on gladiolus inflorescences. The ways of attraction are also discussed.

Materials and Methods

Nine cultivars of gladiolus (Table 1) were grown twice in a random manner in TARI experimental field in September and December, 1986. The bulbs were dipped in 1,000X benomyl solution for 1 hour before planting. No pesticide was applied in the growing period. Plants were left to natural infection by *T. hawaiiensis* (M.) in the field Observations were made when the plants began to bloom.

Table 1. Color Hues of the 9 Cultivars of Gladiolus Used

Cultivar	Color Hue
Albert	Crimson with red blotch on the lower petals
Applause	Rosy with red flecks on the lower petals
Blue Isle	Violet with a white band in the middle of each petal
Nymph	White with crimson flecks
Peter Pears	Pale orange-pink with creamy ill-defined blotch on lower petal which were slightly streaked with orange-scarlet
Red Beauty	Blood-red with velvet texture
T512	Pink with slightly rosy flecks in the center of the flower which had white band in the middle of each petal
T609	Lilac with white flecks at the center of the flower
White Prosperity	Snow white with a violet strip on the lower petals

Experiments I, II-1 and III were conducted in the field, II-2 and IV in the laboratory. The performance of attraction is expressed as No. of thrips/flower or No. of thrips/spike. Data were analyzed by Duncan's multiple range test.

〔Experiment I〕 *Distribution of the Thrips on Gladiolus Inflorescence*

Flowers and buds on an infloresence were classified according to the degree of development: (1) full-bloom stage; (2) half-bloom stage, the length of visible petals were about 6 to 8cm; (3) bud stage I, petals from 3 to 6cm were seen; (4) bud stage II, petals from 0 to 3cm could be observed, and (5) bud stage III, no petal was visible. Flowers and buds of the 9 cultivars were picked and the number of adult *T. hawaiiensis* (M.) was counted. These plants were sampled at random in 5 repetitions on different days with sunshine.

〔Experiment II〕 *Cultivar Preference of the Thrips*

II-1. Field Experiment

Some cultivars, Albert, Applause, Peter Pears, Red Beauty, T512, T609 and White Prosperity, were chosen to observe the differential preference of the thrip in the field. Gladiolus flowers at full-bloom and half-bloom stages were picked and dissected to count the number of the thrips. Five repetitions were conducted on sunny days.

II-2. Laboratory Experiment

Spikes of Albert, Applause, Peter Pears, Red Beauty, T512, T609 and White Prosperity were cut when the petals were still in the buds. Those spikes without detectable *T. hawaiiensis* (M.) were randomly put in containers and moved to a closed room with sunlight shining from a window. When they began to bloom, adult thrips from the field were introduced at the distance approximate 5m away. The inflorescent flowers were dissected for the thrip count after 72 hours. Three repetitions were conducted. Room temperature was 24-28°C.

〔Experiment III〕 *Attraction of the Thrips by the Color Hues of the petals of Six Cultivars*

Six cultivars, Albert, Applause, Peter Pears, T512, T609 and White Prosperity were used in this experiment. Thirty spikes per cultivar were sampled in the field at random. Petals of inflorescent flowers were deprived, and only corolla tubes, stamens and pistils were kept. Flowers still in the buds were removed. For the control, petals were kept. Observations were made and number of *T. hawaiiensis* (M.) recorded after 48 hours. Four repetitions were conducted.

〔Experiment IV〕 *Attraction of the Thrips by the Floral Scent of the Cultivars*

Spikes of Albert, Applause, Peter Pears, Red Beauty, T512, T609 and White Prosperity cultivars, obtained as experiment II-2, were put in a dark room. When the gladiolus began to bloom, adult thrips were introduced as in the experiment II-2. After 72 hours, the inflorescent flowers were picked and dissected. Three repetitions were carried out and the room temperature was 25-27°C.

Results

Most of the adult thrips, *T. hawaiiensis* (M.), were found in the inflorescent gladiolus flowers. The more the flower buds developed, the more attractive they were. Inflorescent flowers were noticed to be the most important source of attraction to the thrip, 4.94 thrips/flower was observed, and there was ca. 1 thrip/semi-blooming flower. On average, almost no thrips were found in bud stages. And buds without petals broken

out were the least effective, and none was found (Table 2).

Table 2. Distribuion of Thrips, *T. hawaiiensis* (M.) on the Inflorescence of Gladiolus

Development Stage	No. of Flowers Examined	No. of Thrips[2]	No. of Thrips/Flower
Full-Bloom	711	3,512	4.94a[3]
Half-Bloom	427	410	0.96b
Bud[1] (I)	334	43	0.13c
Bud (II)	453	20	0.04c
Bud (III)	394	0	0 c

1. Classified According to the Length of the Visible Petals: I. 3-6cm; II. 0-3cm; III. Nothing
2. Only Adult Thrips Were Counted
3. Means with the Same Letter Were Not Significantly Different at 5% Level

Half-blooming gladiolus were less attractive to adult *T. hawaiiensis* (Table 3). The result repeated the observation of table 2. The cultivar of T512 appeared to be the most attractive of all, 1.08 thrips/flower. White Prosperity and T609 had some attraction, with 0.84 and 0.62 thrips found per flower, respectively. The thrip seemed to have no appetite for the other cultivars.

Table 3. Cultivar Preference of Thrips, *T. hawaiiensis* (M.) on Gladiolus in the Field

Cultivar	Half-Bloom			Full-Bloom		
	No. of Flowers Examined	No. of Thrips[1]	Rate[2]	No. of Flowers Examined	No. of Thrips	Rate
Albert	136	19	0.14e[3]	152	135	0.89c
Applause	233	49	0.21de	168	99	0.59c
Peter Pears	195	27	0.14e	459	152	0.33c
Red Beauty	149	56	0.38d	158	66	0.42c
T512	204	221	1.08a	195	2,012	10.32a
T609	129	80	0.62c	122	467	3.83b
White Prosperity	188	158	0.84b	145	289	1.99c

1. Adult Thrips Were Recorded Only
2. No. of Thrips/Flower
3. Means with the Same Letter Were Not Significantly Different at 5% Level

Inflorescent flowers of cultivar T512 again showed strong attraction, 10.32 thrips/flower, to adult *T. hawaiiensis* among the records of the seven cultivars in the field test (Table 3). Swarms of the thrips gushed out when the flowers of T512 were being dissected. Besides, T609 also showed intermediate attraction. Cultivar White Prosperity was a little more inviting to the thrips than the other four, yet the difference was not significant.

The fascination of gladiolus cultivars to the thrips in the laboratory was considerably less than that in the field (Table 4). But cultivar T512 was still the most seductive one, T609 the next and White Prosperity the third. This result was quite similar to that obtained in the field experiment (Table 3).

Depriving the petals from gladiolus flowers decreased the attracting effect by 8-33 folds (Table 5). Corolla without petals of T512, T609 and White Prosperity were still potent to attract the thrips, while Albert, Applause and Peter Pears became less attractive to the thrips.

In the dark, White Prosperity and T512 were equally more attractive to the thrips than the other remaining 5 cultivars. T609 had medium effect but the other four gave poor performance (Table 6).

Table 4. Cultivar Preference of Thrips, *T. hawaiiensis* (M.) on Gladiolus in the Laboratory

Cultivar	No. of Flowers[1] Examined	No. of Thrips[2]	No. of Thrips/Flower
Albert	132	24	0.18cd[3]
Applause	119	12	0.10de
Peter Pears	108	18	0.17d
Red Beauty	127	9	0.07e
T512	136	84	0.62a
T609	120	45	0.38b
White Prosperity	135	36	0.27c

1. Full-Bloom
2. Only Adult Thrips Were Recorded
3. Means with the Same Letter Were Not Significantly Different at 5% Level

Table 5. Attraction of Thrips, *T. hawaiiensis* (M.) by the Color Hues of the Petals of Six Cultivars

Cultivar	Without Petals			With Petals		
	No. of Spikes[1] Examined	No. of Thrips[2]	Rate[3]	No. of Spikes Examined	No. of Thrips	Rate
Albert	120	31	0.26bc[4]	120	378	3.15c
Applause	120	20	0.17c	120	342	2.85c
Peter Pears	120	36	0.30b	120	296	2.47c
T512	120	75	0.63a	120	2,481	20.68a
T609	120	81	0.68a	120	1,953	16.28b
White Prosperity	120	76	0.63a	120	2,127	17.73b

1. Flowers in Bud Stages Were Removed
2. Only Adult Thrips Were Record
3. No. of Thrips/Spike
3. Means with the Same Letter Were Not Significantly Different at 5% Level

Table 6. Attraction of Thrips, *T. hawaiiensis* (M.) by the Floral Scent of the Cultivars in a Dark Room

Cultivar	Flowers[1] No.	Thrips[2] No.	Rate (Thrips/Flower)
Albert	113	7	0.06c[3]
Applause	147	18	0.12c
Peter Pears	130	13	0.10c
Red Beauty	116	8	0.07c
T512	126	42	0.33a
T609	102	24	0.24b
White Prosperity	116	43	0.37a

1. Full-Bloom
2. Only Adult Thrips Were Recorded
3. Means with the Same Letter Were Not Significantly Different at 5% Level

Discussion

During this investigation, many insects have been found on gladiolus inflorescences, such as thrips, aphids, leaf beetles and mirid bugs, with *T. hawaiiensis* (M.)as the major flower-dwelling insect of gladiolus. Insects usually gather around the center of the corolla, many are even drowned in the nectar. The basal part of the corolla tubes of the flowers seemed to be the most favorite site for *T. hawaiiensis* (M.), the stamens and pistils the next, and the sepals the least. Most of the immature thrips dwell in the space between the sepals and the petals. Our observation (Table 2) on the distribution of the thrip indicated that adult *T. hawaiiensis* (M.) were inclined to visit fully blooming gladiolus flowers, and disliked flowers in bud stages. Swarms of flower-visiting insects are generally present in inflorescent gladiolus flowers and thus pollinate the flowers. Thrips have been reported to be pollinators of beet (Imms 1924), *Calluna vulgaris*, *Erica tetralix* and *Hypochaeris radicata* (Hagerup 1950). *Taeniothrips ericae* has been reported to complete its whole life-cycle in the flowers of *Calluna* and often cause pollination (Hagerup 1950). In this respect, thrips may be considered as beneficial insects on the other hand.

Animal-pollinated plants generally provide a convenient alighting place, food, conspicuous coloring and scent to attract the pollinators. The size, shape and arrangement of flowers are involved in insect attraction (Proctor & Yoe 1972). Nectar is one of the important factors of attraction as many insect-pollinated flowers contain nectaries (Wilson & Loomis 1967). Carbohydrates, the main constituents of nectar, are the principal food requirement of adult winged-insects (Proctor & Yoe 1972). The rate of nectar-production and the sugar concentration sometimes vary with the age of the flowers (Jaeger 1957), and those flowers which were highest on a plant or in an inflorescence, produce the least nectar (Proctor & Yoe 1972). According to our preliminary observation in this study, large amount of nectar was found in the inflorescent gladiolus flowers,

much less in the semi-blooming ones, and none in the buds. This could be one of the reasons why the performance of attraction was proportional to the degree of development of the flower buds.

Insect-pollinated flowers are usually brightly colored or scented, sometimes both. Some experiments have confirmed the general belief that insects are attracted to flowers by colors and scents (Wilson & Loomis 1967). According to a well-known principle of physics , a color viewed in the presence of other hues will be more brilliantly than it is viewed alone (Lovell 1918). Studies on effect of background contrast on host-seeking of *Tabanus nigrovittatus* M. pointed out that the attraction of *T. nigroviatttus* M. to gray test panels was significantly greater when contrast against this gray background panel was high (Allen & Stoffolans, Jr. 1986). There were more than one color in an inflorescent gladiolus flower. The brilliant spots or bands near the center of the corolla (Table 1) made the flower more conspicuous than the non-fully blooming ones and thus might seduce more thrips. Inflorescent gladiolus flowers might release some special scents which attract the thrips to fly toward them. Some species of flowers, for example, *Caryophyllacece*, produce scent to attract insects only when their flowers are open (Proctor & Yoe 1972). Shape response of apterous *Myzus persicae* is reported to determine its flying orientation (Hodgson & Elbakhiet 1985). The floral shape is said to be a critical factor for the host-seeking of some tropical bees (Proctor & Yoe 1972). The thrips might also be able to perceive the shape of a fully blooming gladiolus flower.

Flowers usually owe their conspicuousness to a bright-colored corolla or calyx. The bright hues of flowers serve as signals or flags to attract the attention of insects living on pollens and nectar (Lovell 1918). Some flower-visiting insects manifest a preference for certain colors, as honey-bees for blue, butterflies for red, hoverflies for yellow, and carrion-flies for lurid purple (Lovell 1918). *Thrips flavus* like bright red gladiolus flowers most, and white ones the least (Lal & Chandra 1972-74). *T. hawaiiensis* (M.) seemed to like the color hues of violet, lilac, pink and white as they visited the gladiolus cultivars with these colors more frequently (Table 3 & 4). All the efforts to investigate the importance of the color hues alone failed due to the interference of the floral scent. Crepe-paper-made flowers were used to attract the thrip, but it was hard to imitate the combiation of color hues in gladiolus flowers, and the attraction was poor. Therefore, not enough direct evidence was obtained to define the role of color hues in the favorite-flower-seeking of the thrip. As it was not easy to determine which factor was involved in thrip attraction in wide open fields, we started laboratory experiments. The attraction of *T. hawaiiensis* (M.) in the laboratory was far less than that in the field (Table 4). Lack of air flow could be an obstacle to the difusion of floral scent. The sunlight came in from one side only could be another artificial factor which disturbed the moving action of the thrips. Some thrips were found on windows and walls probably because they had been confused. But their preference for certain cultivars was nevertheless similar to what was observed in the field. Experiment III was an effort to judge the importance of combined effect of color hues, floral scent and shape. The gladiolus flowers which had lost their petals lost their seduction to the thrips (Table 5). Similar

phenomena were observed on honey-bees, which ceased to visit the flowers of common pear when their petals were deprived (Lovell 1918). As those petal-deprived-flowers still kept their scent and nectar, the decrease of attraction to the thrip should have something to do with the lack of color index and floral shape. But still few thrips could find the gladiolus flowers without petals. Floral scent should be an important factor as well.

Proctor & Yoe (1972) reported that scent was the means of guidance to beetles approaching flowers of *Arum* from a distance. Attractions were recognized as playing an important part in host-plant selection by *Eurema hecabe mandarina* larvae (Numata et al. 1985). Table 6 suggested that floral scent had a role in attraction. With nothing visible to the thrips, the floral color and shape became useless signals at all. Yet as some thrips still could locate the flowers of gladiolus, and even chose the favorite ones, indicating that the floral scent played an important role in favorite-cultivar-seeking of the thrip. Young (1986) reported that beetles flew to the inflorescence in darkness, suggesting that floral scents were attractants. Kirk (1985) reported that the floral scents significantly increased the attraction of some thrips. The floral scent of gladiolus was hard to detect by human nose, but certain insects were indeed capable of detecting very faint scents (Gibbs 1950). The cultivars T512, T609 and White Prosperity might have some special scents different from the other cultivars, which could guide more thrips flying toward them in darkness (Table 6), even in the abscence of floral petals (Table 5). Hoverflies, *Helophilus pendulus* and *Syrphus balteatus* approached the flowers of *Parnassia palustris* by visual preception, but at very short range, the floral scent induced the insects to alight (Daumann 1932, 1935). It was possible that color hues and their contrast, and floral shape of gladiolus might serve as visual signals guiding the thrips flying toward the inflorescence, and then the floral scent at a closer range attracted the thrips to alight on their favorite corolla.

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花薊馬對數種唐菖蒲品系偏好性之研究[1]

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摘　要

花薊馬，*Thrips hawaiiensis*（M.）對某些唐菖蒲品系之花朵有特殊的偏好性。無論是田間或者實驗室試驗均顯示花薊馬最喜歡T512品種。White Prosperity和T609亦有良好的引誘效果，但其它品系，如：Red Beauty, Applause, Albert和Peter Pears 的引誘效果不佳；結果以引誘率，薊馬蟲數／花或薊馬蟲數／花穗，表示之。當花薊馬在挑選某些唐菖蒲品系時。花的氣味是其判斷的主要因素之一。顏色可能也是重要因素。在唐菖蒲的花序中，盛開的花朵對花薊馬有强烈的引誘效果，但半開者和花苞則不太有吸引力。盛開花朵的形狀、鮮明的顏色對比、特別的氣味與花蜜可能是吸引大量的花薊馬飛向它們的主因。本文著重於探討這些引誘因素和花薊馬間的關係。

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